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COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

Rotating electrical machines –
Part 9: Noise limits

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Rotating electrical machines – Part 9: Noise limits

INTERNATIONAL
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COMMISSION

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ROTATING ELECTRICAL MACHINES –

Part 9: Noise limits

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This commented version (CMV) of the official standard IEC 60034-9:2021 edition 5.0 allows the user to identify the changes made to the previous IEC 60034-9:2003 +AMD1:2007 CSV edition 4.1. Futhermore, comments from IEC TC 2 experts are provided to explain the reasons of the most relevant changes.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60034-9 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This fifth edition cancels and replaces the fourth edition, published in 2003 and its amendment 1, published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) In Table 2 and Table 3 cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 are now covered.
b) This edition adds Table 3 for 60 Hz machines, whereas Table 2, which covers only 50 Hz machines, has no change in levels.
c) In Table 3, grade A is added to harmonize the highest levels seen in IEC and NEMA, whereas grade B was added to harmonize the lowest, more restrictive levels seen in IEC and NEMA.
d) The clause “Determination of noise increments caused by converter supply” has been shifted to Annex B and renamed “Information on typical noise increments caused by converter supply”

The text of this International Standard is based on the following documents:

FDIS	Report on voting
2/2064/FDIS	2/2069/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Acoustic quantities can be expressed in sound pressure terms or sound power terms. The use of a sound power level, which can be specified independently of the measurement surface and environmental conditions, avoids the complications associated with sound pressure levels, which require additional data to be specified. Sound power levels provide a measure of radiated energy and have advantages in acoustic analysis and design.

ROTATING ELECTRICAL MACHINES –

Part 9: Noise limits

1 Scope

This part of IEC 60034:

– specifies test methods for the determination of sound power level of rotating electrical machines;

– specifies maximum A-weighted sound power levels for factory acceptance testing of network-supplied, rotating electrical machines in accordance with IEC 60034-1, having methods of cooling according to IEC 60034-6 and degrees of protection according to IEC 60034-5, and having the following characteristics:

- standard design, either AC or DC, without additional special electrical, mechanical, or acoustical modifications intended to reduce the sound power level
- rated output from 1 kW (or kVA) up to and including 5 500 kW (or kVA)
- rated speed not greater than 3 750 min^{-1}

~~– provides guidance for the determination of noise levels for a.c. cage induction motors supplied by converters.~~

Excluded are noise limits for AC motors supplied by converters. For these conditions see ~~IEC 60034-17~~ Annex B for guidance.

The object of this document is to determine maximum A-weighted sound power levels, L_{WA} in decibels, dB, for airborne noise emitted by rotating electrical machines of standard design, as a function of power, speed and load, and to specify the method of measurement and the test conditions appropriate for the determination of the sound power level of the machines to provide a standardized evaluation of machine noise up to the maximum specified sound power levels. This document does not provide correction for the existence of tonal characteristics.

Sound pressure levels at a distance from the machine may be required in some applications, such as hearing protection programs. Information is provided on such a procedure in Clause 7 based on a standardized test environment.

NOTE 1 This document recognizes the economic reason for the availability of standard noise-level machines for use in non-critical areas or for use with supplementary means of noise attenuation.

NOTE 2 Where sound power levels lower than those specified in Table 1, Table 2 or Table 3 are required, these ~~should be~~ are agreed between the manufacturer and the purchaser, as special electrical, mechanical, or acoustical design may involve additional measures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60034-6, *Rotating electrical machines – Part 6: Methods of cooling (IC Code)*

~~IEC 60034-17, *Rotating electrical machines – Part 17: Cage induction motors when fed from convertors – Application guide*~~

ISO 3741, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms*

ISO 3743-1, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 1: Comparison method for a hard-walled test room*

ISO 3743-2, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 2: Methods for special reverberation test rooms*

ISO 3744, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for anechoic rooms and ~~semi~~ hemi-anechoic rooms*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3747, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – ~~Comparison method in situ~~ Engineering/survey methods for use in situ in a reverberant environment*

ISO 4871, *Acoustics – Declaration and verification of noise emission values of machinery and equipment*

ISO 9614-1, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 1: Measurement at discrete points*

ISO 9614-2, *Acoustics – Determination of sound power levels of noise sources using sound intensity – Part 2: Measurement by scanning*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the sound power radiated by the source under test to the reference sound power [W_o = 1 pW (10^{-12} W)] expressed in decibels

3.2
sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference sound pressure [P_o = 20 µPa (2 × 10^{-5} Pa)] expressed in decibels

3.3
measurement surface index
L_S
ten times the logarithm to the base 10 of the ratio of the measurement surface S to the reference surface [S_0 = 1 m^2] expressed in decibels

3.4
maximum value
value that defines the upper limit without further tolerance

4 Methods of measurement

4.1 Sound pressure level measurements and calculation of sound power level produced by the machine shall be made in accordance with ISO 3744, unless one of the alternative methods specified in 4.3 or 4.4 below applies.

NOTE ~~It is recommended that the hemispherical method be used for machines with shaft height up to 180 mm and the parallelepiped method used for machines larger than 355 mm. Either method may be used for intermediate shaft heights.~~ It is general practice to use the parallelepiped method for all shaft heights. 1

4.2 The maximum sound power levels specified in Table 1, Table 2 and Table 3 or adjusted by Table 4 relate to measurements made in accordance with 4.1.

4.3 When appropriate, one of the methods of precision or engineering grade accuracy, such as the methods of ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3745, ISO 9614-1 or ISO 9614-2, may be used to determine sound power levels.

4.4 The simpler but less accurate method specified in ISO 3746 or ISO 3747 may be used, especially when the environmental conditions required by ISO 3744 cannot be satisfied (for example, for large machines).

However, to prove compliance with this document, unless a correction due to inaccuracy of the measurement has already been applied to the values determined by this method in accordance with ISO 3746 or ISO 3747, the levels of Table 1, Table 2 and Table 3 shall be decreased by 2 dB.

4.5 If testing under rated load conditions, the methods of ISO 9614 are preferred. However, other methods are allowed when the load machine and auxiliary equipment are acoustically isolated or located outside the test environment.

5 Test conditions

5.1 Machine mounting

5.1.1 Precautions

Care should be taken to minimize the transmission and the radiation of structure-borne noise from all mounting elements including the foundation. This can be achieved by the resilient mounting for smaller machines; however, larger machines can usually only be tested under rigid mounting conditions.

Machines tested under load conditions shall be rigidly mounted.

5.1.2 Resilient mounting

The natural frequency of the support system and the machine under test shall be lower than a ~~quarter~~ third **2** of the frequency corresponding to the lowest rotational speed of the machine.

The effective mass of the resilient support shall be not greater than one-tenth of that of the machine under test.

5.1.3 Rigid mounting

The machines shall be rigidly mounted to a surface with dimensions adequate for the machine type (for example by foot or flange fixed in accordance with the manufacturer's instructions). The machine shall not be subject to additional mounting stresses from incorrect shimming or fasteners.

5.2 Test operating conditions

The following test conditions shall apply:

a) The machine shall operate at rated voltage(s), rated frequency or rated speed(s) and with appropriate field current(s) (when applicable). These shall be measured with instruments of an accuracy of 1 % or better.
   - The standard load condition shall be no-load, except for series wound motors.
   - When required, the machine shall be operated at an agreed load condition.

b) Machines shall be tested in their operating position within their specified duty that generates the greatest noise.

c) For an AC motor, the waveform and the degree of unbalance of the supply system shall comply with the requirements of IEC 60034-1.

   NOTE Any increase of voltage (and current) waveform distortion and unbalance will result in an increase of noise.

d) A synchronous motor with adjustable excitation field shall be run with excitation to obtain unity power factor or for large machines tested as a generator.

e) A generator shall be either run as a motor or driven at rated speed with excitation to obtain the rated voltage on open circuit.

f) A machine suitable for more than one speed shall be evaluated over the operating speed range.

g) A motor intended to be reversible shall be operated in both directions unless no difference in sound power level is expected. A unidirectional motor shall be tested in its design direction.

6 Sound power level limits

Where a machine is tested under the conditions specified in Clause 5, the sound power level of the machine shall not exceed the relevant value(s) specified as follows:

a) A machine, other than those specified in b), operating at no-load shall be as specified in Table 1.

b) A single-speed three-phase cage induction motor with cooling classification IC411, IC511, IC611, IC01, IC11, IC21, IC31, IC71 and IC81, at 50 Hz or 60 Hz, shaft heights from 90 up to and including 560, and with rated output not less than 1,0 kW and not exceeding 1 000 kW:
   - operating at no-load shall be as specified in Table 2 and Table 3

- operating at rated load shall be the sum of the values established in Table 2, Table 3 and Table 4
- Grade A in Table 3 is the maximum level that a standard 60 Hz motor shall meet
- Grade B in Table 3 is a reduced level for 60 Hz motors that will meet the more stringent requirements of the end-user
- unless grade B is specifically requested, grade A is to be used as the default noise level for 60 Hz motors.

~~Converter-supplied a.c. machines are excluded from specified limits.~~

NOTE 1 The limits of Table 1, Table 2 and Table 3 recognize class 2 accuracy grade levels of measurement uncertainty and production variations.

NOTE 2 Sound power levels, under full-load condition, are normally higher than those at no-load. Generally, if ventilation noise is predominant the change may be small; but if the electromagnetic noise is predominant the change may be significant.

NOTE 3 The limits are irrespective of the direction of rotation. A machine with a unidirectional ventilator is generally less noisy than one with a bi-directional ventilator. This effect is more significant for high-speed machines, which may be designed for unidirectional operation only.

NOTE 4 For some machines, the limits in Table 1 may not apply for speeds below nominal speed. In such a case, or where the relationship between noise level and load is important, limits should be agreed between the manufacturer and the purchaser.

NOTE 5 For multispeed machines the values in the Table 1 apply.

~~7 Determination of noise increments caused by converter supply~~

~~Noise emissions of electromagnetic origin at the converter supply can be considered as the superposition of:~~

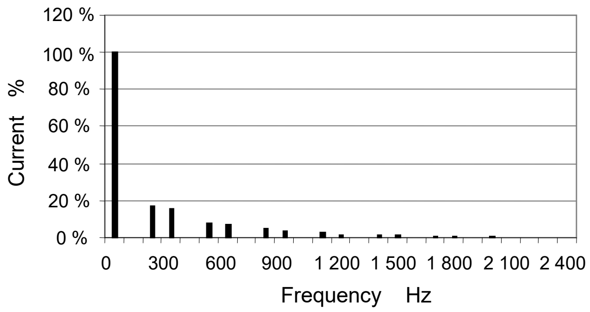
- ~~the noise generated by the voltages and currents of fundamental frequency, which is identical with the noise at sinusoidal supply of the same values, and~~
- ~~an increment caused by voltages and currents at other frequencies.~~

~~Two features mainly influence this increment:~~

~~a) The frequency spectrum at the converter terminals~~

~~Three typical frequency spectra can be identified:~~

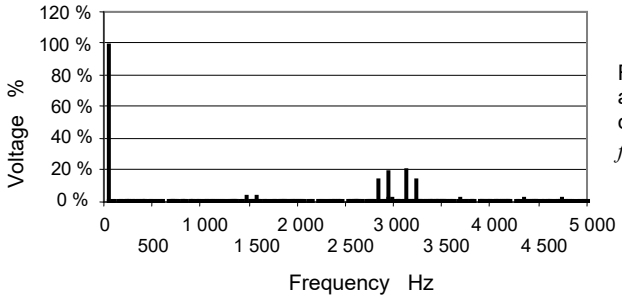
~~1) Spectrum of a block-type current-source converter~~



Frequency spectrum of the currents at the output terminals of a 6-pulse current-source converter
f_1 = 50 Hz

IEC 337/07

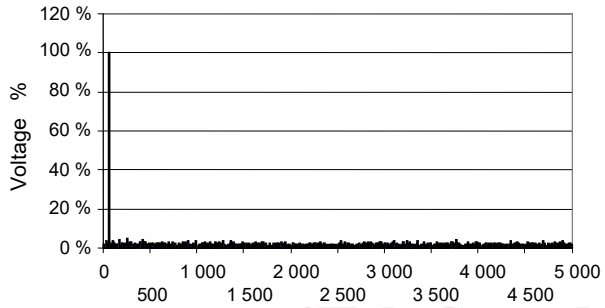
~~2) Spectrum of type A voltage-source converter (characterized by pronounced spikes CLOSE to the switching frequency and its multiples)~~



Frequency spectrum of the voltages at the terminals of a type A voltage-source converter
f_1 = 50 Hz, f_s = 3 kHz

IEC 338/07

~~3) Spectrum of type B voltage-source converter (characterized by a broad voltage spectrum without pronounced spikes.)~~



Frequency spectrum of the voltages of a type B voltage-source converter
f_1 = 50 Hz, f_s average = 4,5 kHz

IEC 339/07

~~Specific considerations are necessary when the spectrum deviates significantly from a typical spectrum.~~

~~b) The resonance frequencies of the motor for the modes of vibration caused by the harmonics~~

~~The relevant resonance frequencies of motors can be grouped according to the following table:~~

~~Shaft height H~~	~~Resonance frequencies of vibration mode r~~			
	~~r = 0~~	~~r = 2~~	~~r = 4~~	~~r = 6~~
~~H ≤ 200 mm~~	~~> 4 000 Hz~~	~~> 600 Hz~~	~~> 4 000 Hz~~	~~> 5 000 Hz~~
~~H ≥ 280 mm~~	~~< 3 000 Hz~~	~~< 500 Hz~~	~~< 2 500 Hz~~	~~< 4 000 Hz~~

~~A magnetically excited tone is generated by the interaction of the fundamental fields of the number of pole-pairs p of the fundamental frequency f_1 at the motor terminals and of one of the harmonic frequencies $n \cdot f_1$, as shown in the relevant frequency spectrum. The tones are of:~~

$$f_r = f_1 \cdot (n \pm 1) = \begin{cases} (n+1) \cdot f_1 \\ (n-1) \cdot f_1 \end{cases}$$

$$r = p \pm p = \begin{cases} 2p \\ 0 \end{cases}$$

~~Usually combinations with $n \cdot f_1$, close to the switching frequency generate objectionable tones.~~

~~A reasonable increase of the audible noise is to be expected, if the frequency and the vibration mode of a tone are close to the corresponding values of the resonant structure of the motor. In~~

~~some cases, objectionable tones may be avoided by changes to the parameter assignment of the converter.~~

~~The following table shows the expected increase of noise, at converter supply, when compared to the noise at sinusoidal supply, with the same fundamental values of voltage and frequency.~~

~~Increments of noise~~

~~Kind of converter~~	~~Case~~	~~Expected increment~~
~~Block-type current-source converter~~	~~6-pulse or 12-pulse~~	~~1 to 5 dB(A)~~ ~~The higher values relate to motors with low ventilation noise. Increment depends on load.~~
~~Type A voltage-source converter~~	~~High frequency voltages of high amplitudes excite resonances of the motor~~	~~Up to 15 dB(A)~~ ~~Increment does not depend on load. Initial calculation possible by adequate software.~~
	~~High frequency voltages of high amplitudes do not excite resonances of the motor~~	~~1 to 5 dB(A)~~ ~~Increment does not depend on load.~~
~~Type B voltage-source converter~~	~~Broad voltage spectrum without pronounced spikes~~	~~5 to 10 dB(A)~~ ~~Increment does not depend on load.~~

7 Determination of sound pressure level

Sound pressure levels are not required as part of this document.

~~If requested, an A-weighted sound pressure level may be determined directly from the sound power level as follows:~~

$$L_p = L_W - 10\lg\left(\frac{S}{S_0}\right)$$

~~where~~

~~L_p is the sound pressure level in a free-field over a reflecting plane at 1 m distance from the machine;~~

~~L_W is the sound power level determined according to this standard;~~

~~S_0 is 1,0 m^2;~~

~~S is the area of the surface enveloping the machine at a distance from the machine of 1 m according to ISO 3744 and the following rule:~~

~~Shaft height~~	~~Surface area, S~~
~~mm~~	~~m^2~~
~~≤280~~	~~Hemisphere~~
~~>280~~	~~Parallelepiped~~

However, if requested by end user to provide pressure levels, for example in accordance with Annex A, it shall be per agreement between user and manufacturer. An A-weighted sound pressure level may be determined directly from the sound power level as follows: